(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 511 547 B1

# (12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
**11.12.1996 Bulletin 1996/50**

(51) Int Cl.[6]: **E21B 10/16**, E21B 10/52

(21) Application number: **92106450.7**

(22) Date of filing: **14.04.1992**

## (54) Rock bit

Gesteinsbohrmeissel

Trépan de roche

(84) Designated Contracting States:
**DE FR GB IT NL**

(30) Priority: **01.05.1991 US 693900**

(43) Date of publication of application:
**04.11.1992 Bulletin 1992/45**

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Printed by Jouve, 75001 PARIS (FR)

## Description

The present invention relates generally to a rock bit of the type as described in the preamble of claim 1.

Earth boring rock bits for drilling oil and gas wells typically have three rotatable cutters that roll over the bottom of a borehole as the bit rotates. Each cutter is generally conical and has a frustoconical heel surface that passes near the borehole sidewall as the cutter rotates. One type of rock bit, known as a tungsten carbide insert bit or TCI bit, has wear resistant inserts secured in holes formed in the cutters. Such inserts are usually made of tungsten carbide.

For each cutter, the inserts are arranged in circumferential rows on the conical surface of the rotatable cutter at various distances from the heel surface. The row nearest, but not on the heel surface is known as the gage row. The gage row of inserts cuts rock at the gage of the hole. The heel surface extends upwardly along the wall of the hole drilled by the gage row.

In the types of bits as defined in the preamble of claim 1, such as shown in US-A-3,727,705, certain cutters have gage row structure that includes staggered rows located thereon. The staggered rows comprise two rows of inserts alternately spaced so that the grip portion of the inserts do not interfere.

In this and other prior art bits (see FIGURE 4), the inserts on the gage row are oriented in such a manner to cause the cutting elements to cut both the borehole bottom and sidewall. This combined cutting action compromises the insert because the cutting action operating on the borehole bottom is usually a crushing and gouging action while the cutting action operating on the sidewall is a scraping action. Ideally, the crushing action calls for a tough insert while the scraping action calls for a hard insert. As a result, one grade of tungsten carbide cannot ideally perform both functions.

These bits obviated this problem by having the heel row of inserts provided with a flat cutting surface parallel to the heel surface, and basically contact the sidewall while the gage row of inserts contacts the borehole bottom. However, it has been found that these rows are separated by such a distance as not to allow optimization of each.

U.S. Patent Nos. 2,774,570 and 2,774,571 show such arrangements. In each instance, the heel row of inserts is still physically compromised because the lower portion of each insert must still engage the borehole bottom while only the outside portion scrapes the sidewall. In addition, because the heel row is separated from the gage row, there is still a large portion of the sidewall that the gage row must scrape against as it passes through the hole bottom and continues up the sidewall.

As a result, the inserts of the heel rows of these prior art bits cannot be as hard as that recommended for the sidewall scraping action because they must be tough enough to crush the bottom hole formation. In like manner, the gage row of inserts cannot be as tough as the interior rows of inserts because they must perform a large portion of scraping action on the borehole sidewall.

The present invention as defined in claim 1 minimizes the above-mentioned shortcomings by providing a rolling cone rock bit with a plurality of cutters each mounted on the body of the bit to rotate about an axis. Each cutter has a generally frusto-conical support surface for rolling contact with the bottom of a borehole, and a heel surface at the base of the cutter adjacent to the sidewall of the borehole. A plurality of wear resistant inserts positioned on the support surface are arranged in circumferential rows, each insert being generally cylindrical with a projected crown area profile and having a central axis. One of the rows of inserts next to the heel surface is a row of gage inserts, with each gage insert being oriented to have its axis extend partiallly radially outward to enable the gage insert to engage the borehole bottom. Each gage insert defines a cutting surface projected crown area profile taken through a section through the centerline of the cone. A plurality of heel inserts located near the gage inserts are at an acute angle with respect to the gage inserts in a direction away from the apex of the cone. Each insert defines a cutting surface projected crown area profile taken through a section through the centerline of the cone. The crown area profile of a heel insert, when rotated around the cone to the same plane as a gage insert crown area profile, overlaps the gage insert crown area profile to enable the heel inserts to slidably engage the borehole sidewall.

Since the heel row inserts scrape against the wall, they are made of a harder grade of tungsten carbide than the gage row inserts, and the gage row inserts are tougher than the heel row inserts. Preferably, the heel row insert crown area profiles are located up the borehole sidewall within three millimeters of the gage row insert crown area profiles.

The above noted features and advantages of the present invention will be more fully understood upon a study of the following description of a preferred embodiment in conjunction with the detailed drawings wherein:

FIGURE 1 is a perspective view of a three cone rock bit utilizing gage row cutters made in accordance with the present invention;

FIGURE 2 is an enlarged perspective view of one of the cones shown in FIGURE 1;

FIGURE 3 is a fragmentary sectional view of the cone through the centerline of the cone located in a borehole; and

FIGURE 4 is a fragmentary sectional view of a prior art cone showing the location of a conventional heel row insert.

FIGURE 1 illustrates a drill bit or rock bit, generally indicated by an arrow 10, having a threaded pin section 11 for securing to the bottom end of a drill string. The rock bit further includes a main body 12 having a plurality

of legs 13, 14 and 15 extending downwardly therefrom. Each leg includes a bearing pin (not shown in FIGURE 1) extending toward the center of the bit. Three cone shaped cutters 16 are rotatably mounted on the bearing pins and are adapted to roll along the bottom of a borehole as the bit is rotated.

The cutters 16 tend to roll along the hole bottom much like a wheel except that because the axes of the bearing pins are offset from the axis of the bit, and because of the geometry of the cones, a true roll of the cones is not possible. Therefore, in addition to the rolling motion, a small sliding motion is imparted thereto which would be analogous to the movement of an automobile tire that is out of alignment.

Each cutter cone 16 has a plurality of wear resistant inserts 20 interferingly secured by the insert grip 90 in mating holes drilled in the support surface of the cutter cone. Preferably the inserts 20 are constructed from sintered tungsten carbide.

The inserts 20 are located in rows that extend circumferentially around the generally conical surface of each cutter. Certain of the rows are arranged to intermesh with other rows of the other cutters so that the entire bottom of the hole is drilled.

Referring now to FIGURE 2, as mentioned previously, each cutter is generally conically shaped with a nose area 21 at the apex of the cone and a heel surface 22 at the base of the cone. The heel surface 22 is frustoconical and is adapted to pass near the wall of the borehole as the cutters rotate about the borehole bottom. The row of inserts 20 closest to the heel surface 22 is called the gage row 23. In practice of this invention, the gage row inserts are further separated into a first row of gage inserts 24 and a second row of heel inserts 25.

As shown in FIGURE 3, which is a fragmentary cross section through the centerline of a cutter 16, each of the gage inserts 24 is oriented with its axis extending radially outwardly and downwardly to engage the borehole bottom. The cutting profiles of the inserts are illustrated in a cross section as seen in FIGURE 3. Each of the heel inserts 25, on the other hand, is with its axis oriented outwardly and downwardly at a greater angle from the centerline of the cone. The heel inserts are oriented at an acute angle to the gage inserts in a direction away from the apex of the cutter cone to more closely face the sidewall of the borehole.

During drilling operations, a tremendous amount of weight from the drill string is applied to the bit 10 as it is rotated. As the inserts 20 of the first three rows, beginning with the nose row, rotated with the cutter, they eventually come in contact with the rock formation on the bottom of the hole. The imprint made on the formation is created by the insert contacting the formation with its trailing side, rolling on the formation about its apex, and then exiting with the last contact being made by its leading side. During this rolling movement, the offset of the cone axis causes each insert 20 to slide a small amount which causes the imprint to become somewhat elongated. This combined rolling and sliding motion along with extreme loads involved causes the formation contacted by the insert to be crushed, with little chips being broken off thereby.

Because of the high loads involved with this crushing action, the inserts 20 must be made of an extremely tough grade of tungsten carbide.

The gage row of inserts 24 also contact the hole bottom in a similar manner. However, prior to the present invention, these inserts 24 also performed a scraping action along the borehole sidewall before they make their imprint on the borehole bottom (see FIGURE 4). As mentioned previously, this necessitated making the gage row inserts harder to accommodate the scraping function and minimize wear which can cause the hole to be drilled under the desired gage or diameter. Unfortunately, when one makes a tungsten carbide insert harder, it necessarily becomes less tough.

Because of these compromises, the gage rows of inserts in prior art rock bits suffered from breakage problems. As a result, inserts 26 had to be placed on the heel surfaces of the cones to ensure the heel surface integrity after the gage inserts broke or wore down. Since such inserts were separated a relatively large distance $D_2$ from the gage inserts (FIGURE 4), they do not come into play and do not contact the sidewall until after the gage inserts break or wear to a certain point, the problems concerning gage insert breakage continued.

The present invention minimizes such a problem by having the heel row inserts 25 interleaved between the the gage inserts with their cutting surface profiles being overlapped. The crowns of the gage row inserts and heel row inserts are separated by only a distance $D_1$ in the cutting surface profile as illustrated in FIGURE 3. This enables the heel inserts 25 to engage the borehole sidewall at points much lower in the borehole and much sooner in the cutting cycle than previous heel inserts. The distance $D_1$ is preferably within four millimeters in a 20 cm diameter rock bit.

The crown of the insert is the part of the projected area of the insert that contacts the intact rock formation, as illustrated in FIGURE 3. By scraping away the borehole sidewall in those lower areas before the gage inserts have the opportunity to engage the sidewall, the gage inserts 24 are spared from having to do a large amount of scraping. As a result, there would be a much smaller amount of gage insert scraping compared to the prior art, and this amount does not require the gage inserts to make any compromises from a toughness standpoint. Since the vast majority of the cutting action of the gage inserts is the crushing and gouging action occurring on the borehole bottom, the gage row inserts 24 can now be made of the same tough grade of tungsten carbide as the inner rows of inserts.

If one were to isolate attention on a single cutting insert as the bit rotates within a borehole, its path would be seen to be a modified planetary motion. The cutter

cone rotates about the journal which is slightly offset from the axis of the bit. As the bit rotates, the cone rolls on the borehole bottom with a small sliding motion imparted thereto because of the geometry of the cones and the journal offset. During this motion, the insert eventually moves down into engagement with the borehole bottom. As it touches down on a particular location, the insert rotates on that spot but with a small sliding motion. For the most part, the insert acts on the formation spot in a crushing action in addition to a small scraping action. As a result, such inserts have to be tough to resist the comprehensive forces acting on the insert. This greatly overrides the need to be hard to resist the small abrasive forces acting on the insert because of the small sliding.

If the insert is a gage insert, the same planetary motion occurs except that the planetary orbit is the largest. As the gage insert touches down on the hole bottom, the same type of movement is involved, i.e. the insert rolls over the spot with a small sliding motion. However, because of the journal offset, the gage insert would also contact a portion of the sidewall during a portion of its travel. This, of course, results in almost pure scraping, and the gage insert normally would have to be harder than an inner row insert because of the large abrasive forces acting thereon.

As a result, conventional gage inserts had the problem of having to resist the high compressive forces encountered with the hole bottom, and the high abrasive forces encountered with the sidewall of the borehole. Unfortunately, compromises had to be made because tungsten carbide inserts cannot have a maximum toughness and maximum hardness at the same time. Because of this, the gage inserts usually always wore faster than the inner rows of inserts.

Prior bits sometimes avoid any sliding motion because of the true roll aspects of the cone, i.e. zero journal offset and zero oversize angle. However, this was not always the case, even for hard formation bits. Usually for such bits, only one row of inserts would become the "drive row" and assumed the true roll condition. All other rows would have some sliding associated with them. Therefore, unless the outer gage row would become the drive row, a certain amount of sliding would occur and the sliding forces acting on the sidewall would have to be dealt with.

In today's drilling, the vast majority of rock bits are soft and medium formation bits that have journal offset and do not have any "true roll" capabilities.

In this invention, to optimize drilling with a bit having offset and no true rolling, there is a single substantially overlapping row of inserts near the heel of the cutter cone with each alternate gage row insert 24 oriented toward the hole bottom to cut the hole bottom while the other of each alternate heel row insert 25 being oriented to the sidewall to cut the sidewall.

Since sidewall scraping is going to exist a set of heel row inserts is oriented to do substantially all of the scraping and leave very little scraping for the other set of gage row inserts which are left to attack the hole bottom. As a result, the first set can be made of a hard material and the second set of a tough material.

Basically, this is accomplished by two means, i.e. the orientation of the two inserts (one toward the hole bottom and the other toward the sidewall) and the close proximity of the insert projection profiles. The closeness is shown by dimension $D^1$ in Figure 3, which is preferably less than four millimeters.

Moreover, since the heel row inserts 25 are restricted to mostly scraping, they can be made of a very hard tungsten carbide or they can also be coated with super hard abrasives such as polycrystalline diamond.

Although the inserts 24 are shown as hemispherical, they can also be constructed of different conventional shapes such as chisels. In addition, the heel row inserts 25 can have their abrasive surfaces be slightly spherical, flat, or some other configuration and still come within the invention.

It will of course be realized that various other modifications can be made in the design and operation of the present invention. Thus, while the principal preferred construction and mode of operation of the invention have been illustrated and described in what is now considered to represent its best embodiments, it should be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described and illustrated.

**Claims**

1. A rock bit (10) for drilling a borehole, having a bit body (12), a plurality of cutters (16) each mounted on the bit body (12) to rotate About an axis, each cutter (16) having a generally frusto-conical support surface for rolling contact with the bottom of a borehole, each cutter (16) further having a heel surface (22) at the base thereof adjacent to the sidewall of the borehole, and a plurality of wear resistant inserts (20,24) positioned on the support surface and being arranged in circumferential rows, each insert (20,24) being generally cylindrical with a projected crown area profile and having a central axis, one of the rows of inserts being positioned next to the heel surface (22) defining a row (23) of gage inserts, with each gage insert (24) oriented to have its axis extend partially radially outward to enable the gage insert (24) to engage the borehole bottom, each gage insert (24) further defining a cutting surface projected crown area profile taken through a section through the centreline of the cone, and a plurality of heel inserts (25) located near the gage inserts (24) at an acute angle with respect to the gage inserts (24) in a direction away from the apex of the cone, **characterised in that** each heel insert (25) further defines a cutting surface projected crown area pro-

file taken through a section through the centreline of the cone, the crown area profile of the heel insert (25), when rotated around the cone to the same plane as a gage insert crown area profile, overlapping the gage insert crown area profile to enable the heel inserts (25) to slidably engage the borehole sidewall.

2. The rock bit of claim 1 wherein the heel inserts (25) are interleaved between the gage inserts (24).

3. The rock bit of any of the preceding claims wherein the inserts (20,24,25) are made of tungsten carbide.

4. The rock bit of claim 3 wherein the heel row inserts (25) are made of a harder grade of tungsten carbide than the gage row inserts (24).

5. The rock bit of claim 4 wherein the gage row inserts (24) are made of the same tough grade of tungsten carbide as the other rows of inserts (20).

6. The rock bit of any of the preceding claims wherein the heel row insert crown area profiles are located up the borehole sidewall within four millimetres of the gage row insert crown area profiles.

7. The rock bit of any of the preceding claims wherein the heel inserts (25) are coated with an outer layer of polycrystalline diamond.

8. The rock bit of any of the preceding claims wherein the rotational axes of the cutters (16) are each offset from the axis of the bit body (12).

9. The rock bit of any of the preceding claims wherein the cutters (16), when rotating, define a substantially flat surface corresponding to the bottom of a borehole, and a generally cylindrical surface corresponding to the side wall of a borehole.

**Patentansprüche**

1. Gesteinsbohrmeißel (10) zum Bohren eines Bohrloches mit einem Meißelkörper (12), einer Vielzahl von Schneidköpfen (16), die jeweils am Meißelkörper (12) zum Drehen um eine Achse montiert sind, wobei jeder Schneidkopf (16) eine im allgemeinen kegelstumpfförmige Tragfläche für einen rollenden Kontakt mit dem Boden eines Bohrloches aufweist, jeder Schneidkopf (16) ferner eine rückwärtige Oberfläche (22) an seiner Basis benachbart der Seitenwand des Bohrloches sowie eine Vielzahl von verschleißfesten Einsätzen (20, 24) aufweist, die an der Tragfläche positioniert und in Umfangsreihen angeordnet sind, wobei jeder Einsatz (20, 24) im wesentlichen zylindrisch mit einem vorstehenden, gewölbten Flächenprofil ausgebildet ist und eine zentrale Achse aufweist, wobei eine der Einsatzreihen benachbart der rückwärtigen Oberfläche (22) angeordnet ist und eine Reihe (23) von Kalibereinsätzen definiert, wobei jeder Kalibereinsatz (24) so ausgerichtet ist, daß seine Achse teilweise radial nach außen weist, damit der Kalibereinsatz (24) mit dem Boden des Bohrloches in Eingriff treten kann, wobei jeder Kalibereinsatz (24) ferner ein vorstehendes, gewölbtes Flächenprofil einer Schneidfläche definiert, bezüglich eines Schnitts durch die Mittellinie des Kegels, und mit einer Mehrzahl von rückwärtigen Einsätzen (25), die nahe den Kalibereinsätzen (24) unter einem spitzen Winkel bezüglich der Kalibereinsätze (24) in einer Richtung weg vom Scheitelpunkt des Kegels angeordnet sind, **dadurch gekennzeichnet**, daß jeder rückwärtige Einsatz (25) ferner ein vorstehendes, gewölbtes Flächenprofil der Schneidfläche im Schnitt durch die Mittellinie des Kegels aufweist, wobei das gewölbte Flächenprofil der rückwärtigen Einsätze (25), wenn sie um den Kegel zur gleichen Ebene wie ein gewölbtes Flächenprofil des Kalibereinsatzes gedreht wird, das gewölbte Flächenprofil des Kalibereinsatzes überlappt, so daß die rückwärtigen Einsätze (25) gleitend mit der Seitenwand des Bohrloches in Eingriff treten können.

2. Gesteinsmeißel nach Anspruch 1, wobei die rückwärtigen Einsätze (25) zwischen die Kalibereinsätze (24) eingefügt sind.

3. Gesteinsmeißel nach einem der vorangegangenen Ansprüche, wobei die Einsätze (20, 24, 25) aus Wolframcarbid hergestellt sind.

4. Gesteinsmeißel nach Anspruch 3, wobei die Einsätze (25) der rückwärtigen Reihe aus einem Wolframcarbid eines höheren Härtegrades als die Einsätze (24) der Kaliberreihe hergestellt sind.

5. Gesteinsmeißel nach Anspruch 4, wobei die Einsätze (24) der Kaliberreihe aus dem gleichen Hochleistungs-Wolframcarbid wie die anderen Reihen der Einsätze (20) hergestellt sind.

6. Gesteinsmeißel nach einem der vorstehenden Ansprüche, wobei die gewölbten Flächenprofile der Einsätze der rückwärtigen Reihe bezüglich der Seitenwand des Bohrloches innerhalb von 4 mm höher angeordnet sind als die gewölbten Flächenprofile der Einsätze der Kaliberreihe.

7. Gesteinsmeißel nach einem der vorstehenden Ansprüche, wobei die rückwärtigen Einsätze (25) mit einer äußeren Schicht aus polykristallinem Diamant beschichtet sind.

8. Gesteinsmeißel nach einem der vorstehenden Ansprüche, wobei die Drehachsen der Schneidköpfe (16) jeweils gegenüber der Achse des Meißelkörpers (12) versetzt sind.

9. Gesteinsmeißel nach einem der vorstehenden Ansprüche, wobei die Schneidköpfe (16) bei ihrer Drehung eine im wesentlichen flache Oberfläche, die dem Boden eines Bohrlochs entspricht, und eine im wesentlichen zylindrische Oberfläche definieren, die der Seitenwand eines Bohrlochs entspricht.

**Revendications**

1. Trépan de roche (10) pour percer un trou de forage, ayant un corps de trépan (12), plusieurs dispositifs de découpe (16) chacun étant agencé sur le corps de trépan (12) pour tourner autour d'un axe, chaque dispositif de découpe (16) ayant une surface de support de manière générale tronconique pour venir en contact roulant avec le fond d'un trou de forage, chaque dispositif de découpe (16) ayant en outre une surface de talon (22) au niveau de la base de celui-ci adjacente à la paroi latérale du trou de forage, et plusieurs éléments rapportés résistant à l'usure (20, 24) positionnés sur la surface de support et étant agencés dans des rangées circonférentielles, chaque élément rapporté (20, 24) étant de manière générale cylindrique en ayant un profil de surface couronne en saillie et ayant un axe central, l'une des rangées d'éléments rapportés étant positionnée après la surface de talon (22) définissant une rangée (23) d'éléments rapportés de gabarit, chaque élément rapporté de gabarit (24) étant orienté pour avoir son axe s'étendant partiellement radialement vers l'extérieur pour permettre à l'élément rapporté de gabarit (24) de venir en contact avec le fond du trou de forage, chaque élément rapporté de gabarit (24) définissant en outre un profil de surface de couronne en saillie formant surface de découpe, pris dans une section transversale traversant l'axe du cône, et plusieurs éléments rapportés de talon (25) situés à proximité des éléments rapportés de gabarit (24) au niveau d'un angle aigu par rapport aux éléments rapportés de gabarit (24) dans une direction s'éloignant du sommet du cône, caractérisé en ce que chaque élément rapporté de talon (25) définit de plus un profil de surface de couronne en saillie formant surface de découpe pris dans une section transversale traversant l'axe du cône, le profil de surface de couronne de l'élément rapporté de talon talon (25), lorsqu'il toume autour du cône dans le même plan qu'un profil de surface de couronne d'élément rapporté de gabarit, recouvre le profil de surface de couronne d'élément rapporté de gabarit pour permettre aux éléments rapportés de talon (25) de venir en contact coulissant avec la paroi latérale du trou de forage.

2. Trépan de roche selon la revendication 1, dans lequel les éléments rapportés de talon (25) sont intercalés entre les éléments rapportés de gabarit (24).

3. Trépan de roche selon l'une quelconque des revendications précédentes, dans lequel les éléments rapportés (20, 24, 25) sont constitués de carbure de tungstène.

4. Trépan de roche selon la revendication 3, dans lequel les éléments rapportés de la rangée de talon (25) sont constitués d'un carbure de tungstène de qualité plus dure que les éléments rapportés d'une rangée de gabarit (24).

5. Trépan de roche selon la revendication 4, dans lequel les éléments rapportés d'une rangée de gabarit (24) sont constitués de carbure de tungstène de même qualité de dureté que les autres rangées d'éléments rapportés (20).

6. Trépan de roche selon l'une quelconque des revendications précédentes, dans lequel les profils de surface de couronne d'éléments rapportés d'une rangée de talon sont situés vers le haut de la paroi latérale du trou de forage, à moins de quatre millimètres des profils de surface de couronne d'éléments rapportés d'une rangée de gabarit.

7. Trépan de roche selon l'une quelconque des revendications précédentes, dans lequel les éléments rapportés de talon (25) sont revêtus d'une couche extérieure de diamant polycristallin.

8. Trépan de roche selon l'une quelconque des revendications précédentes, dans lequel les axes de rotation des dispositifs de découpe (16) sont chacun décalés de l'axe du corps de trépan (12).

9. Trépan de roche selon l'une quelconque des revendications précédentes, dans lequel les dispositifs de découpe (16) lorsqu'ils tournent, définissent une surface à peu près plate correspondant au fond d'un trou de forage, et une surface de manière générale cylindrique correspondant à la paroi latérale d'un trou de forage.

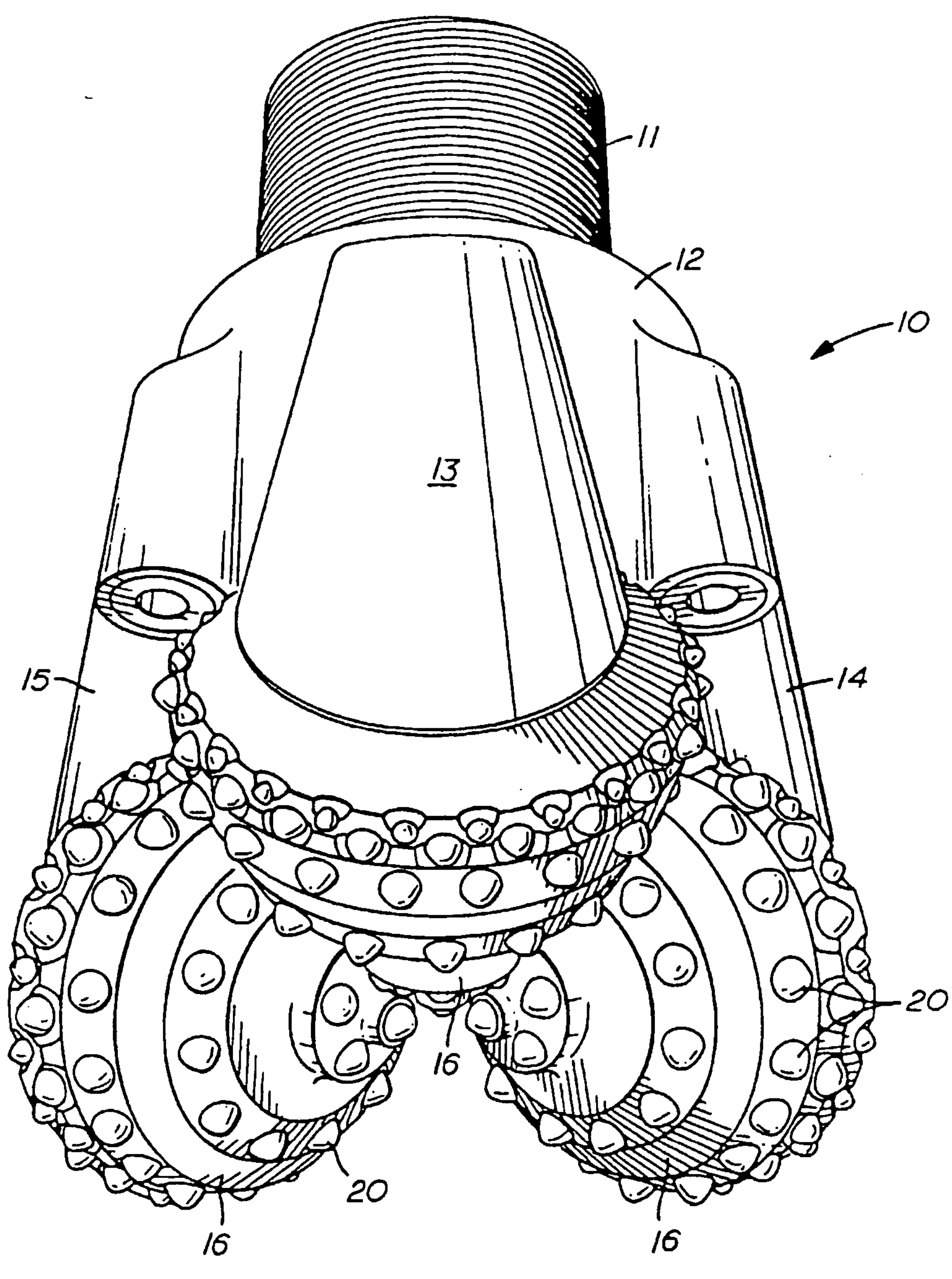


FIG. 1

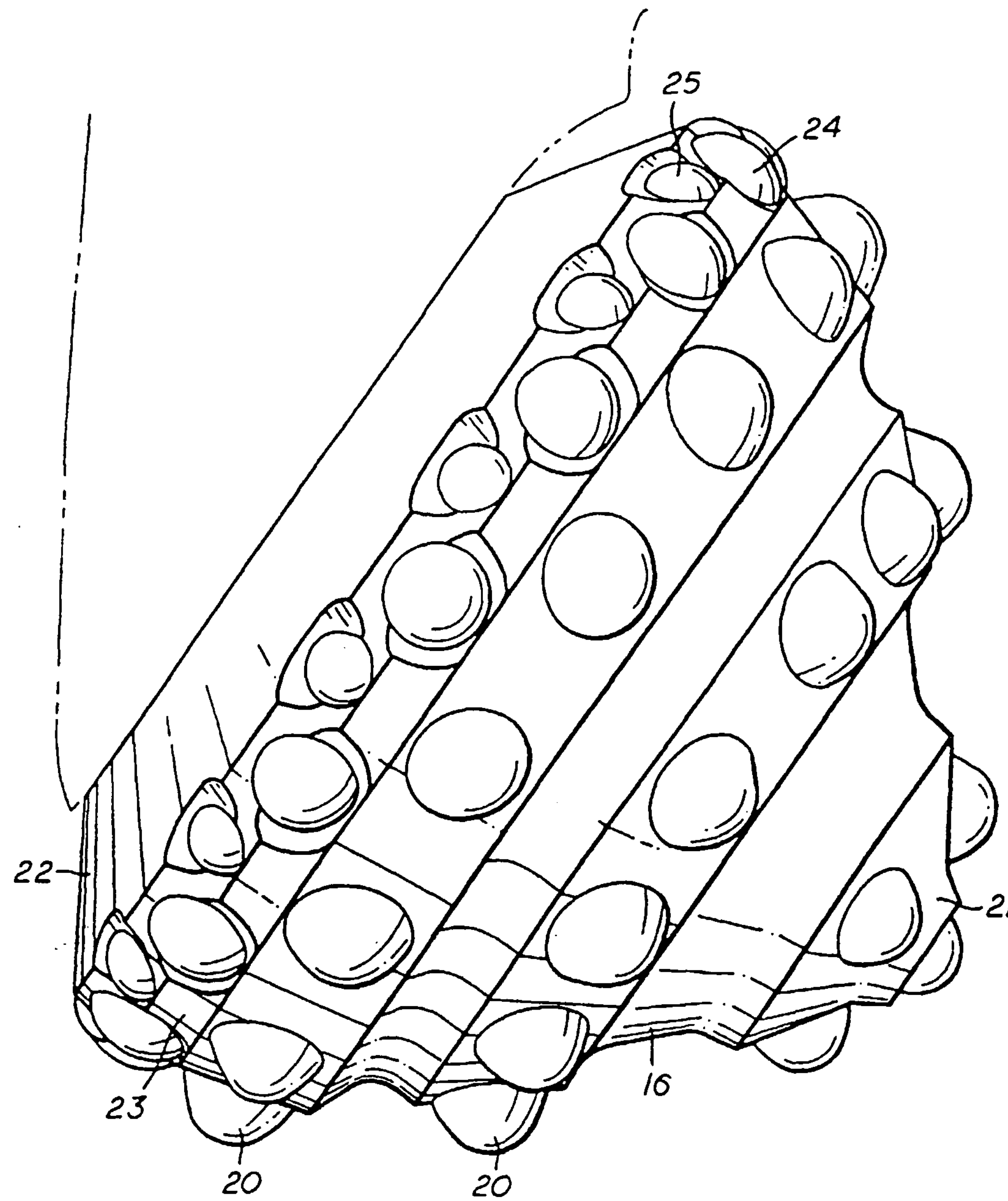


FIG. 2

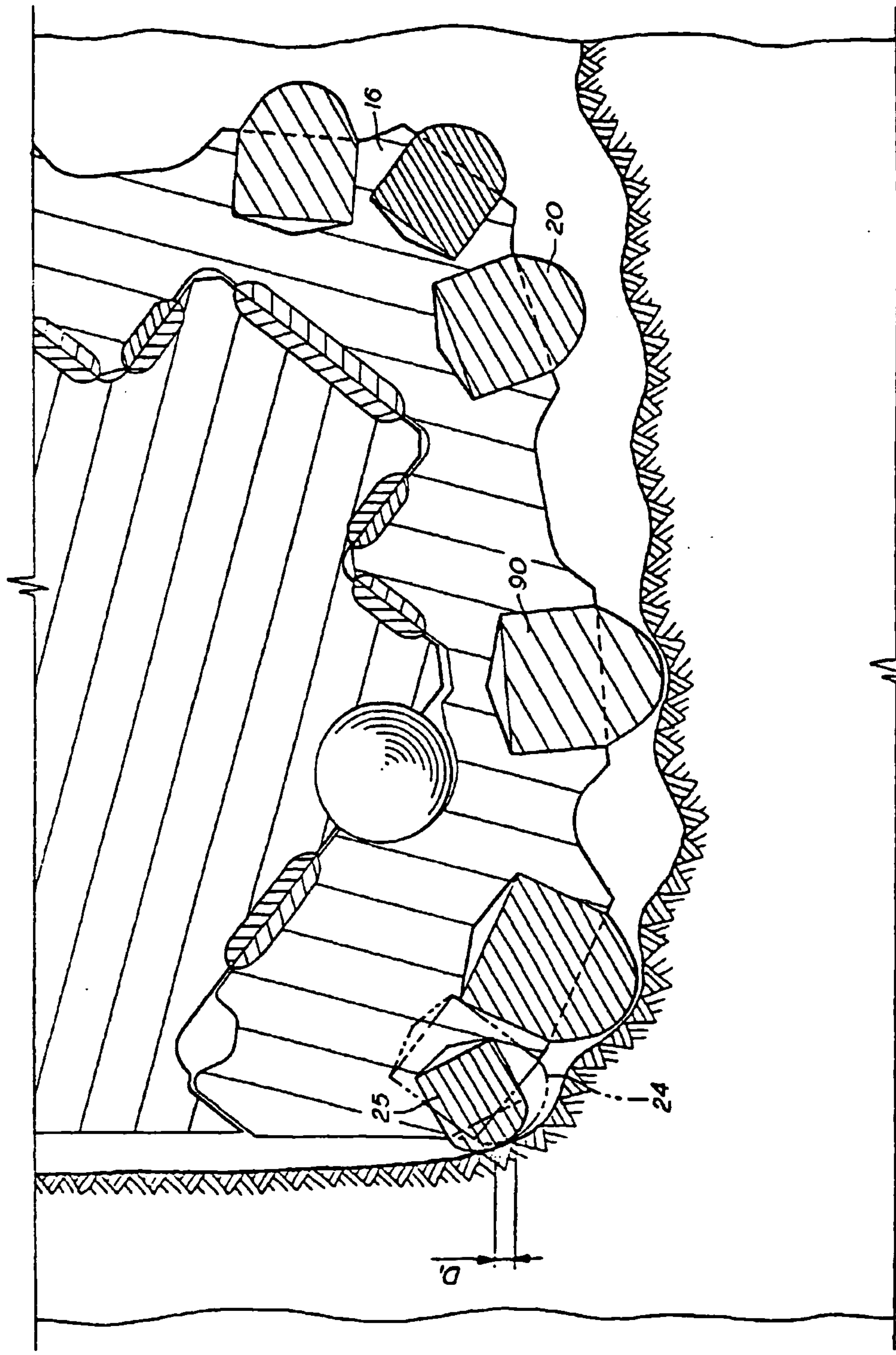


FIG. 3

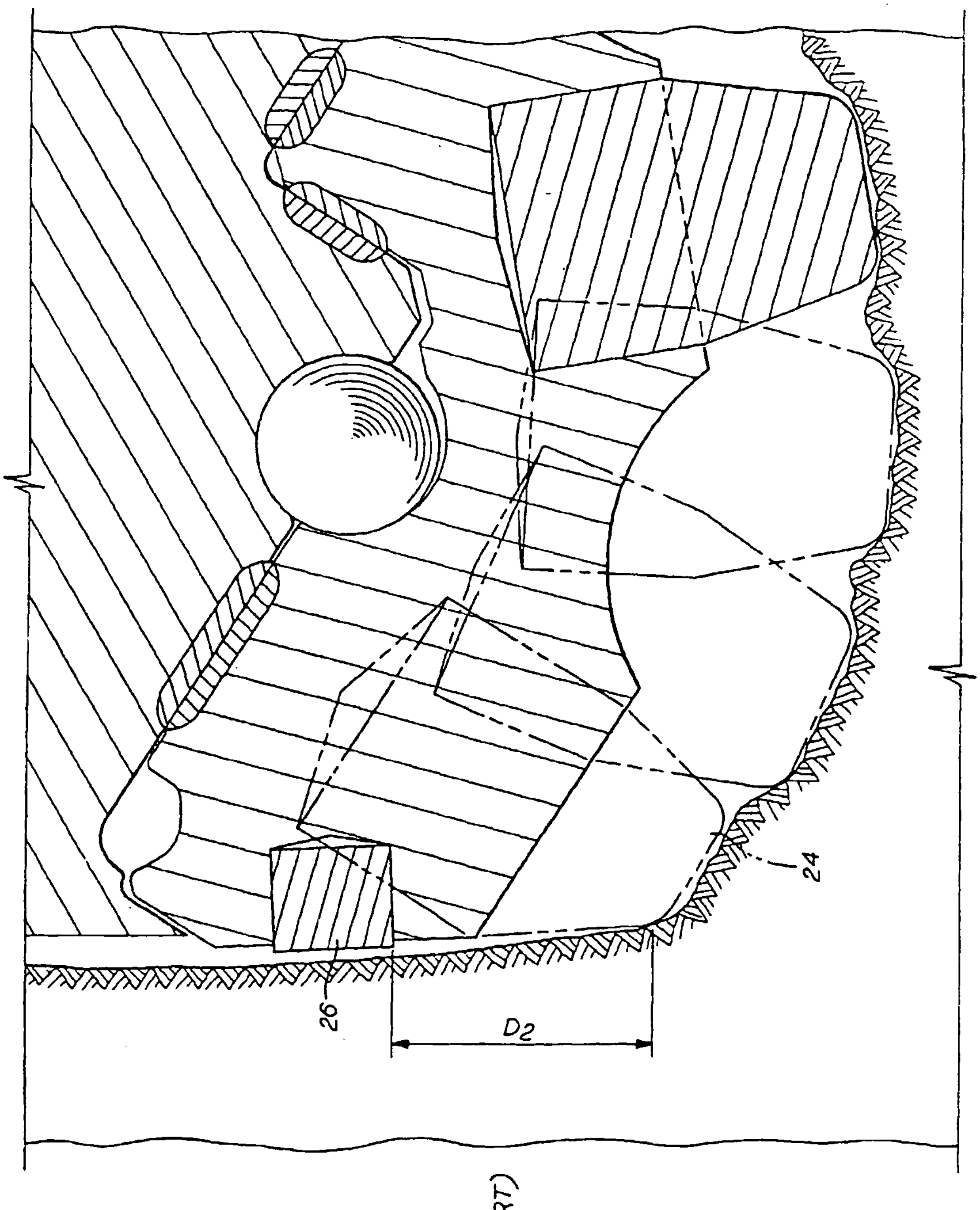


FIG. 4
(PRIOR ART)